Source_code

September 1, 2020

1 Image Clustering (using CNN)

- Problem Statement: You are provided with a dataset of ~5k 512x512 images, your program should accept an 512x512 input image and return N images from the provided dataset similar to the input image. To solve this problem, building an AutoEncoder model is recommended.
- Dataset: https://drive.google.com/file/d/1VT-8w1rTT2GCE5IE5zFJPMzv7bqca-Ri/view?usp=sharing
- Evaluation Method
  - Your code submission will be evaluated based code quality and on how accurate it is able to find similar images
    - simple score of C/N
    - C = no. of correct similar images returned
    - N = no. requested images
  - Plus points, for finding similar images with respect to unique feature
    - simple score of F/N
    - F = no. of images returned with the unique feature specific to the input image
    - N = no. requested images
  - Bonus points, if the provided dataset was clustered into K groups
  - Quality of Code based on Modularity, Reusability, Maintainability, Readability
- Details
  - Full Name : Sreeyapureddy Sai Srikar Reddy
  - Mail ID : saisrikarreddy98@gmail.com
  - Link to repository for code / Colab / script files uploads : https://github.com/SaiSrikarReddy/Avantari_Image_Clustering
  - Small documentation on procedure, coding stack followed : https://github.com/SaiSrikarReddy/Avantari_Image_Clustering/blob/master/Documentation_with_

[1]:

```python
# Importing packages
from keras.preprocessing import image
import numpy as np
from keras.applications.vgg16 import preprocess_input
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten, BatchNormalization
from keras.layers import Conv2D, MaxPooling2D
from tqdm import tqdm
import matplotlib.pyplot as plt
import os
import math
from collections import Counter
```

[2]:

```
# checking the image shape
import cv2
img_path = "../input/animal-faces/afhq/train/wild/flickr_wild_000003.jpg"
img = cv2.imread(img_path)
print (img.shape)
```

```
(512, 512, 3)
```

1.1 1. Generating features from images using CNN

[3]:

```
# CNN algorithm with 4 convolutional layers, 2 Max pooling layers, 2 Dropout␣
 ↪layers and 2 Batch Normalization layers
def CNN_0():
    model = Sequential()
    model.add(Conv2D(24, kernel_size=(7,7),activation='relu',input_shape=(224,␣
 ↪224, 3)))
    model.add(BatchNormalization())
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Dropout(0.5))
    model.add(BatchNormalization())
    model.add(Conv2D(50, (5,5), activation='relu'))
    model.add(Conv2D(90,(5,5),activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Dropout(0.5))
    model.add(Conv2D(120, (3,3), activation='relu'))
    return model
```

[4]:

```
# Model summary
My_model = CNN_0()
My_model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 218, 218, 24)      3552
_________________________________________________________________
batch_normalization (BatchNo (None, 218, 218, 24)      96
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 109, 109, 24)      0
_________________________________________________________________
dropout (Dropout)            (None, 109, 109, 24)      0
_________________________________________________________________
```

```
batch_normalization_1 (Batch (None, 109, 109, 24)      96
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 105, 105, 50)      30050
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 101, 101, 90)      112590
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 50, 50, 90)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 50, 50, 90)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 48, 48, 120)       97320
=================================================================
Total params: 243,704
Trainable params: 243,608
Non-trainable params: 96
_________________________________________________________________
```

[5]:

```python
# https://stackoverflow.com/a/57451142/10348126   - A part of code is taken from this link
def creating_feature(file):
    img = image.load_img(file, target_size=(224, 224))
    img_data = image.img_to_array(img)
    img_data = img_data.astype('float32')
    img_data = img_data/255
    img_data = img_data.reshape(1,224,224,3)
    feature = My_model.predict(img_data)
    feature_np = np.array(feature)
    feature_list = (feature_np.flatten())
    return feature_list
```

[6]:

```python
# Generating features based on the CNN algorithm and Storing in a dictonary.
feature_list = []
check_list = {}
for dirname, _, filenames in os.walk('/kaggle/input/dataset'):
    for filename in tqdm(filenames):
        file = os.path.join(dirname, filename)
        file_name = file.split("/")[-1]
        feature_value = creating_feature(file)
        feature_list.append(feature_value)
        check_list[file_name] = feature_value
```

```
0it [00:00, ?it/s]
100%|      | 4738/4738 [03:30<00:00, 22.47it/s]
```

[8]:

```python
type(check_list)
```

[8]:

```
dict
```

```
[9]: # length of each feature is 276480 after flatten and stored in the form of␣
      ↪numpy array
     print("Length:",len(check_list['0.jpg']))
     print("Feature_map:", check_list['0.jpg'])
```

```
Length: 276480
Feature_map: [0.03127097 0.         0.         … 0.         0.0300002  0.
]
```

Test Image - 1328.jpg Testing on sample image and finding similarity and displaying the top 15 similar images

```
[10]: clustering_img_path = '../input/dataset/dataset/1328.jpg'
      feature = creating_feature(clustering_img_path)
      img = cv2.imread(clustering_img_path)
```

```
[11]: type(feature)
```

```
[11]: numpy.ndarray
```

Cosine similarity is to find the similarity between two features. If cosine similarity is high between two features then they are most likely to be same animal.

```
[12]: # https://stackoverflow.com/a/18424953/10348126
      def cosine_similarity(v1,v2):
          "compute cosine similarity of v1 to v2: (v1 dot v2)/{||v1||*||v2||)"
          sumxx, sumxy, sumyy = 0, 0, 0
          for i in range(len(v1)):
              x = v1[i]; y = v2[i]
              sumxx += x*x
              sumyy += y*y
              sumxy += x*y
          return sumxy/math.sqrt(sumxx*sumyy)
```

```
[13]: def top_similarity(feature):
          feature_check_list = {}
          for i in tqdm(check_list):
              obtained_feature = check_list[i]
              value = cosine_similarity(obtained_feature,feature)
              feature_check_list[i] = value
          #results = sorted([(key, value) for (key, value) in feature_check_list.
       ↪items()], reverse = True)
          return feature_check_list
```

```
[14]: output_similarity = top_similarity(feature)
```

```
100%|          | 4738/4738 [46:30<00:00,  1.70it/s]
```

1.1.1 > Sorting the top 15 images similar to test image

[15]:

```
# Sorting the values in dictonary and picking the top 15 values
# https://www.geeksforgeeks.org/
 ↪python-program-to-find-the-highest-3-values-in-a-dictionary/
k = Counter(output_similarity)
high = k.most_common(15)
for i in high:
    print(i[0]," :",i[1]," ")
```

```
1328.jpg  : 1.0
3867.jpg  : 0.9560385266306173
452.jpg  : 0.9540249541139376
2491.jpg  : 0.9519551133889456
1369.jpg  : 0.9510063452347932
4636.jpg  : 0.9500390419133415
4238.jpg  : 0.9498005329201525
3520.jpg  : 0.9497633845228972
1359.jpg  : 0.948889486635964
3120.jpg  : 0.9488495721813585
2909.jpg  : 0.9483349811329916
1377.jpg  : 0.9480993996916315
191.jpg  : 0.9477285193826422
632.jpg  : 0.9472543933728574
1220.jpg  : 0.9469315271470357
```

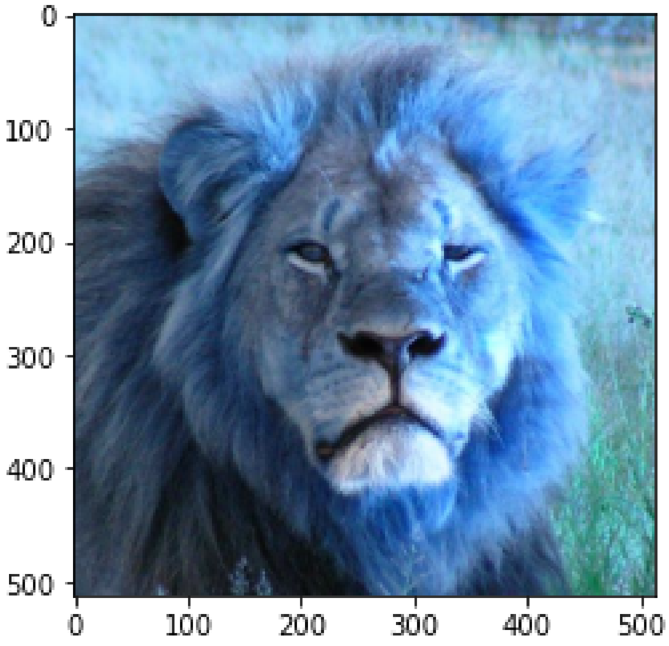
1.1.2 * Test Image

[16]:

```
output = []
for i in high:
    output.append(cv2.imread('../input/dataset/dataset/'+ i[0]))
plt.imshow(output[0])
```

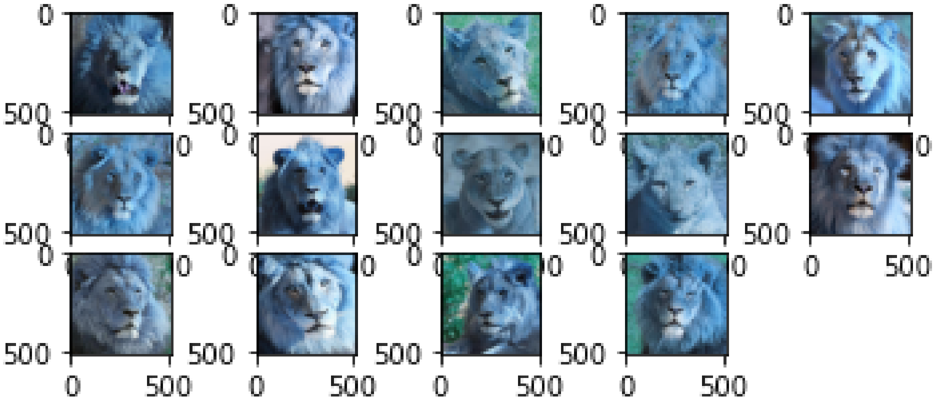
[16]:

```
<matplotlib.image.AxesImage at 0x7fd3caf43610>
```



1.1.3 Output for the test image the top 15 similar images to the test image.

```
[17]: for i in range(1,len(output)):
          plt.subplot(5, 5, i)
          plt.imshow(output[i])
      plt.show()
```



1.2 2. Clustering

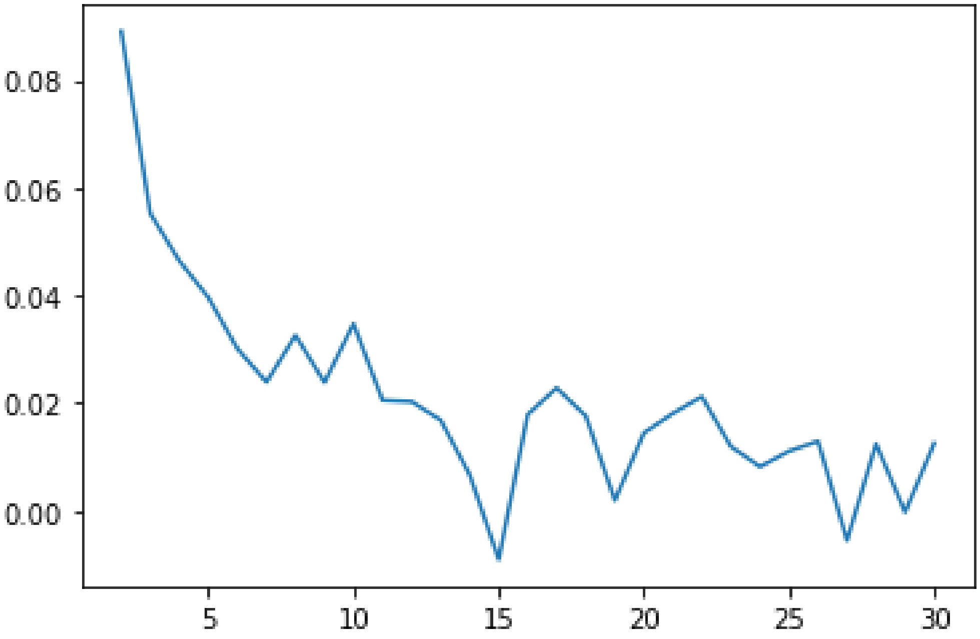
1.2.1 Finding the optimal clusters

```
[12]: from sklearn.cluster import KMeans
      from sklearn.metrics import silhouette_score

      sil = []
      kmax = 30

      # dissimilarity would not be defined for a single cluster, thus, minimum number␣
       ↪of clusters should be 2
      for k in range(2, kmax+1):
          kmeans = KMeans(n_clusters = k).fit(feature_list[:250])
          labels = kmeans.labels_
          sil.append(silhouette_score(feature_list[:250], labels, metric =␣
       ↪'euclidean'))
```

1.2.2 The peak is at 7. So, the optimal clusters are 7

```
[15]: plt.plot(range(2,31), sil)
      plt.show
```

```
[15]: <function matplotlib.pyplot.show(*args, **kw)>
```



1.2.3 > As Kmeans clustering consumes most of the memory. A random sample of 250 images were clustered.

[67]:

```
from sklearn.cluster import KMeans
kmeans = KMeans(n_clusters = 7).fit(feature_list[:250])
predict = kmeans.predict(feature_list[:250])
labels = kmeans.labels_
```

1.2.4 > The Silhouette score is 0.045. That indicate overlapping clusters.

1.2.5 > Less input data may be one of the reason for less score.

[69]:

```
# https://scikit-learn.org/stable/modules/clustering.html#silhouette-coefficient
from sklearn import metrics
score = metrics.silhouette_score(feature_list[:250], labels, metric='euclidean')
print(score)
```

```
0.045191515
```

1.2.6 > Storing the image names from check_list dictonary and storing in a dictonary.

[64]:

```
Image_names = []
m = 0
for i in check_list:
    if m<250:
        Image_names.append(i)
        m = m + 1

print(len(Image_names), len(predict))

cluster_dict = {}
for i in range(0,250):
    cluster_dict[l[i]] = predict[i]
```

```
250 250
```

1.2.7 > Flipping the keys and values, so that for each cluster there may be multiple images.

1.2.8 > One key, multiple values like wise one cluster multiple images.

[66]:

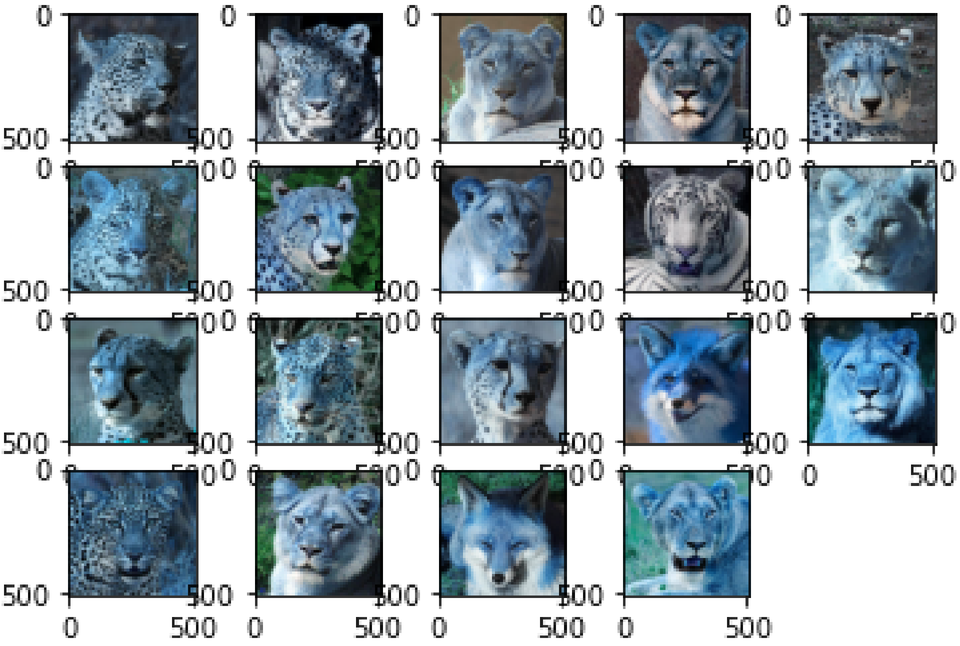
```
# https://www.geeksforgeeks.org/
 ↪python-find-keys-with-duplicate-values-in-dictionary/
final_dict = {}

for key, value in cluster_dict.items():
    if value not in final_dict:
        final_dict[value] = [key]
    else:
        final_dict[value].append(key)
print(final_dict[0])
print(final_dict[1])
```

```
['4642.jpg', '3680.jpg', '2026.jpg', '2434.jpg', '2349.jpg', '234.jpg',
'2765.jpg', '4291.jpg', '3177.jpg', '3702.jpg', '2004.jpg', '1085.jpg',
'765.jpg', '948.jpg', '70.jpg', '3398.jpg', '3781.jpg', '2310.jpg', '4237.jpg',
'2111.jpg']
['1846.jpg', '2553.jpg', '2040.jpg', '2464.jpg', '2544.jpg', '3106.jpg',
'3291.jpg', '138.jpg', '1217.jpg', '1382.jpg', '4688.jpg', '64.jpg', '4734.jpg',
'1685.jpg', '53.jpg', '1089.jpg', '3764.jpg', '3845.jpg', '1041.jpg',
'1721.jpg', '4271.jpg', '1891.jpg', '1415.jpg', '2502.jpg', '2055.jpg']
```

1.2.9 > For each cluster 15 images are displayed accordingly.

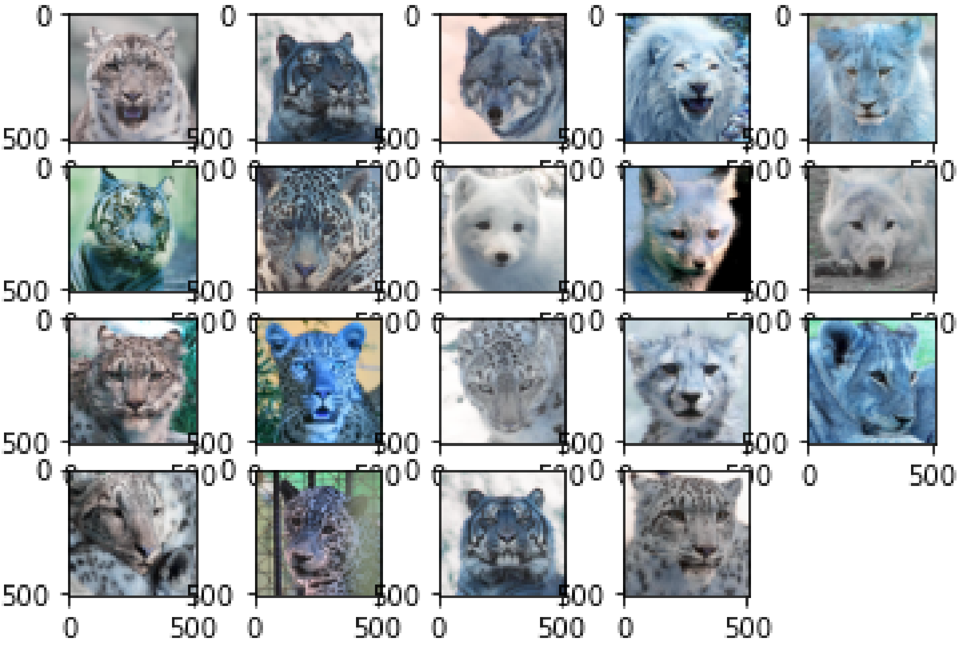
[56]:

```
# cluster 0
output = []
for i in final_dict[0][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```

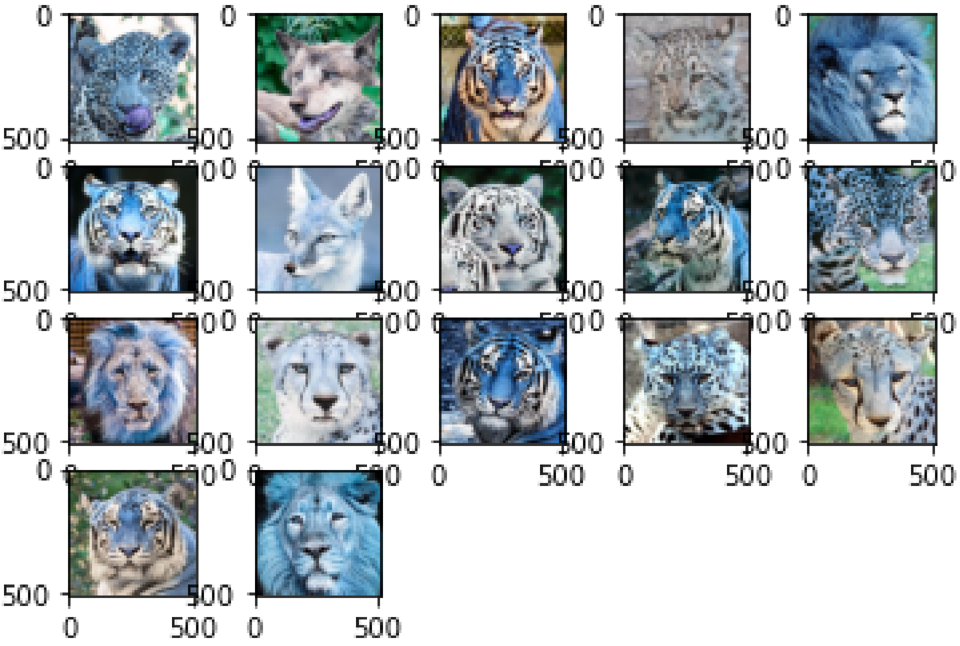


[57]:

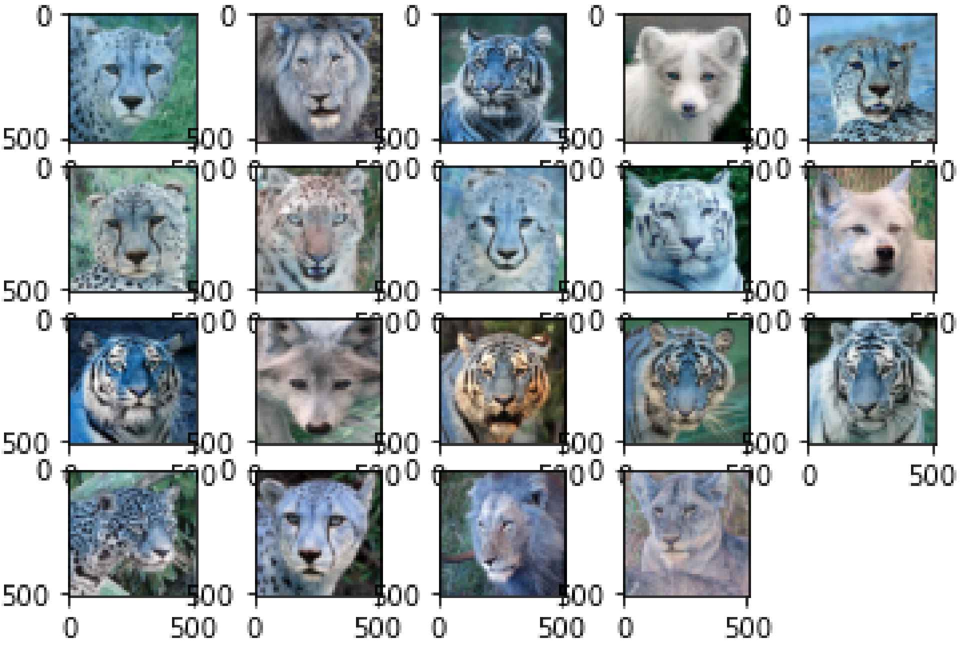
```
# cluster 1
output = []
for i in final_dict[1][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```



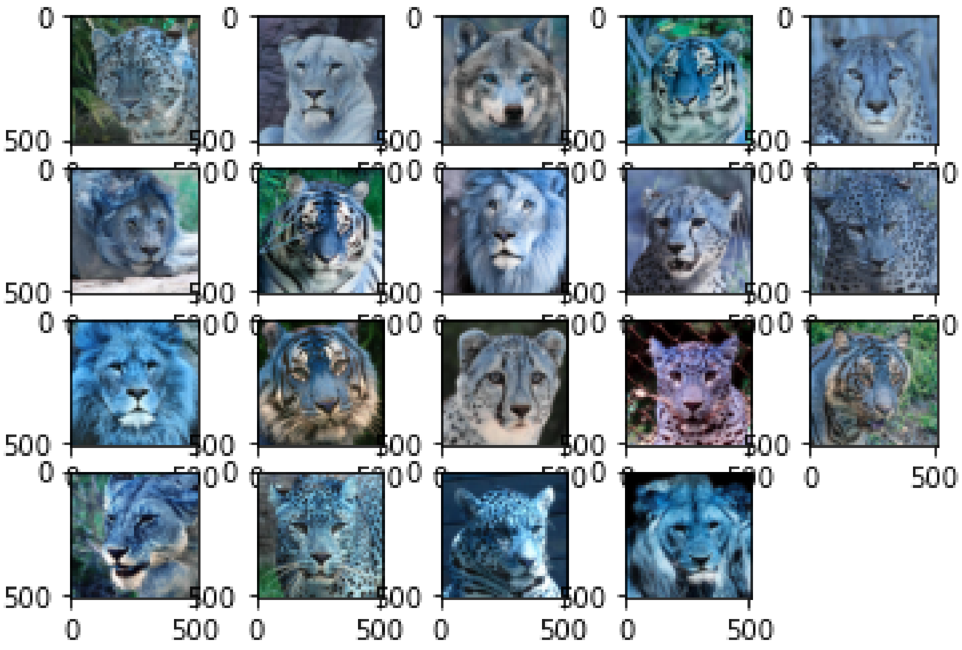
[58]:
```
# cluster 2
output = []
for i in final_dict[2][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```



[59]:
```
# cluster 3
output = []
for i in final_dict[3][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```

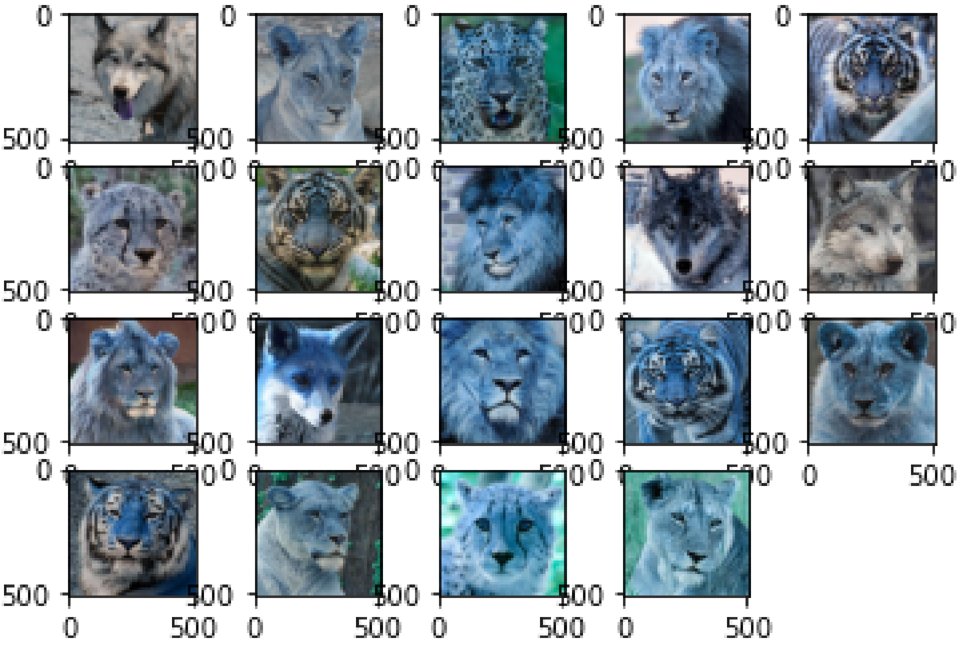


```
[60]: # cluster 4
output = []
for i in final_dict[4][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```

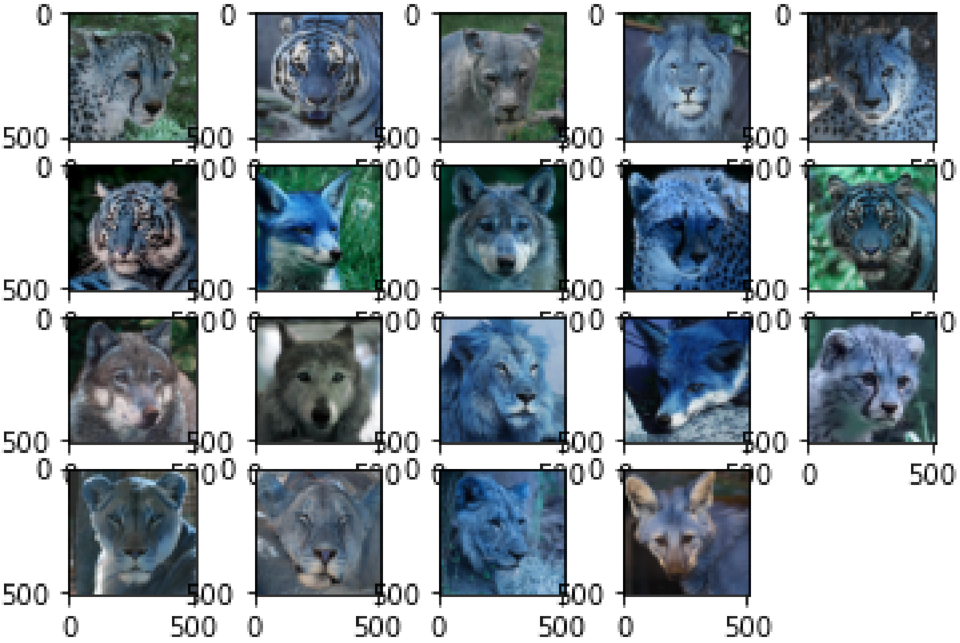


[61]:

```
# cluster 5
output = []
for i in final_dict[5][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```



```
[62]: # cluster 6
output = []
for i in final_dict[6][:20]:
    output.append(cv2.imread('../input/dataset/dataset/'+ i))
for i in range(1,len(output)):
    plt.subplot(4, 5, i)
    plt.imshow(output[i])
plt.show()
```



1.2.10 > The accuracy is low in case of clustered outputs because of a small sample.

1.3 References:

1. https://keras.io/
2. https://stackoverflow.com/a/57451142/10348126
3. https://stackoverflow.com/a/18424953/10348126
4. https://medium.com/analytics-vidhya/how-to-determine-the-optimal-k-for-k-means-708505d204eb
5. https://medium.com/@franky07724_57962/using-keras-pre-trained-models-for-feature-extraction-in-image-clustering-a142c6cdf5b1
6. https://www.geeksforgeeks.org/python-find-keys-with-duplicate-values-in-dictionary/
7. https://www.geeksforgeeks.org/python-program-to-find-the-highest-3-values-in-a-dictionary/
8. https://scikit-learn.org/stable/modules/clustering.html#silhouette-coefficient